Tabique constructions in the Municipalities Association of *Terra Fria do Nordeste Transmontano*

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ABSTRACT

Tabique is one of the main Portuguese traditional building techniques which basically use natural and local building materials such as earth and timber. A *tabique* building component such as a wall is built up using a simple timber structure covered by an earth based mortar on both sides. The earth based mortar has an important role in this building system technology since it not only protects the internal timber structure but it also acts as finishing element. Meanwhile, earth has the advantage of being abundant, natural, local and recycled giving to this technique a special importance in the sustainability context.

It has been noticed that this traditional building technique has an expressive incidence in the region of *Trás-os-Montes and Alto Douro,* Portugal. Taking into account that the *Trás-os-Montes and Alto Douro* region is very large, there was the necessity to divide it in to more manageable areas. The manageable areas are the six Municipalities Associations, which are: *Alto Tâmega, Terra Quente Transmontana, Terra Fria do Nordeste Transmontano, Vale do Douro Norte, Vale do Douro Sul* and *Douro Superior*. This research work is focused on the Municipalities Association of *Terra Fria do Nordeste Transmontano*. This, combined with the scarcity of scientific studies concerning this type of construction in this region, motivated this research work that uses some constructions as sampling and which is focused on an experimental study to identify the chemical and mineralogical composition of the coating material / filler used, the species of wood and the hardness of the nails.

Keywords: *Tabique, sustainability, raw materials.*

1. Introduction

A *tabique* building component such as a wall consists of a timber coated on both sides with a earth-based mortar. Thus, the *tabique* constructions can be considered as a reference model of sustainability in the context of Civil Engineering.

During the process of this research, an exhaustive and detailed survey of the *tabique* buildings existing in the region under study was carried out, as well as, the identification of building materials used. This research work also intends to stimulate the community for conservation and preservation of this type of buildings.

The research presented here is focused on the Municipalities Association of *Terra Fria of Nordeste Transmontano* (AMTFNT). We tried to find the maximum of *tabique* buildings existing in the area.

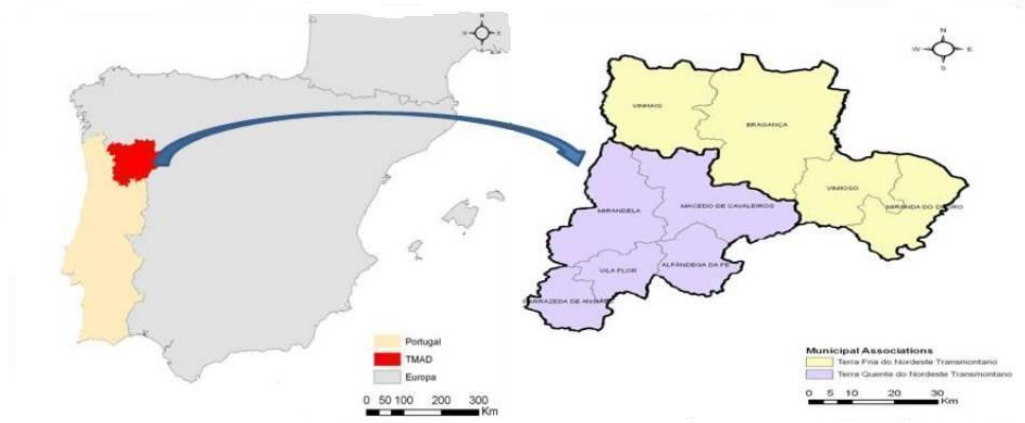
Several material samples of the coating/filling, of the timber structure and nails were collected from different *tabique* buildings found in the AMTFNT. The experimental work of material identification characterization were performed following the procedures already used in others similar research works done in this context [1-9].The granulometric analysis was performed at the Laboratory of Materials and Soils of *Trás-os-Montes e Alto Douro* University (UTAD). The analysis of elementary chemical composition was performed by Scanning Electron Microscopy / Energy Dispersive Spectroscopy (SEM / EDS). The analysis of mineralogical composition was done by X-ray. These last two experimental tests were held in the Scanning Microscopy Unit of UTAD. Meanwhile, the identification of the wood specie use in the timber structure was done in the Foresty Department of UTAD and the identification of the type of metal used in the nails which were used to connect the timber elements was performed in the Mechanic Laboratory of UTAD.

This paper is structured as following: firstly, a brief description of the area under study is presented. Secondly, a brief description of the tabique building technique is delivered. Thirdly, the adopted research strategy and a description of the fieldwork done are introduced. Fourthly, the experimental results are presented and analyzed. Finally, the main conclusions are drawn.

2. AMTFNT

AMTFNT is one of the six Associations of Municipalities of the region of *Trás-os-Montes and Alto Douro* which is the northeast part of Portugal, Figure 1.

The four Municipalities of the AMTFNT are *Vinhais, Bragança, Vimioso* and *Miranda do Douro,* Figure 1.



a) Peninsula Ibérica b) Municipalities of the AMTFNT

Figure 1: AMTFNT

3. *Tabique* constructions

A *tabique* building component such as a wall consists of a timber structure made up of vertical boards connected by a lath (horizontal slats) which are connected together by metal nails. This structural system is then coated with a material believed to be based on earth.
The *tabique* buildings studied in AMTFNT are in general, single-family houses (dwellings); mostly they have two floors and feature a relevant stage of deterioration. The building elements which are most representative are partition and exterior walls, located in general in the upper floors, Figure 2, [1-9].

They are mainly from the XVII and XIX century. They started to fall into disuse when the reinforced concrete and the ceramic bricks were introduced.

a) Exterior wall b) Partition wall

Figure 2: Examples of the most representative elements of *tabique*

4. Research strategy and fieldwork

Taking into account that the area under study has a big extension, it was necessary to organize and plan the field work in order to achieve efficiently the proposed objectives and similarly to Martinho et al [3], Cepeda [4], Cruz et al [5], and Pinto et al [9]. Therefore, the field work consisted of the following logic sequential tasks: (i) to visit all the four councils areas in order to select the tabique constructions to be detailed studied and to interview retired builders; (ii) to contact the building owner of each construction and to ask for permission; (iii) to visit the constructions, making an extensive photographic report of the construction details, measuring the buildings and

its constructive elements, and getting material samples for the experimental characterization studies to be made at laboratories.

Twenty three selected constructions were considered of being representative samples of the existing tabique constructions in the AMTFNT, Figure 3.

a) Building 1 b) Building 2 c) Building 3 d) Building 4
e) Building 5 f) Building 6 g) Building 7 h) Building 8
i) Building 9 j) Building 10 k) Building 11 l) Building 12
m) Building 13 n) Building 14 o) Building 15 p) Building 16
q) Building 17 r) Building 18 s) Building 19 t) Building 20
u) Building 21 v) Building 22 w) Building 23

Figure 3: *Tabique* buildings studied in the AMTFNT

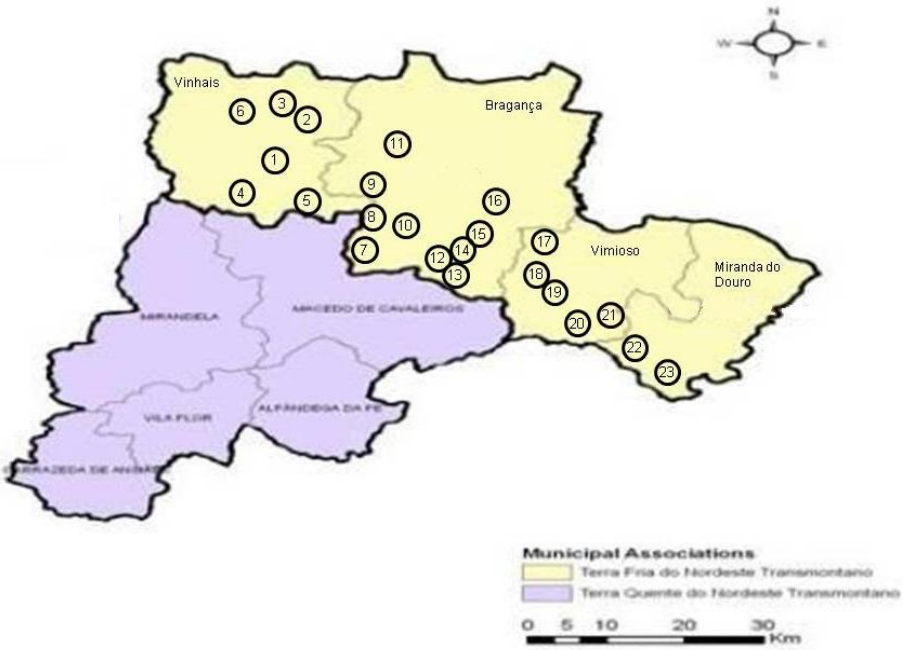


Figure 4: Localization of the tabique buildings

Table 1: GPS coordinates of each building

Building number	GPS coordinates		Building number	GPS coordinates	
1	$41^0$51'20'' N	$6^0$54'36'' W	13	$41^0$34'05'' N	$6^0$43'15'' W
2	$41^0$51'15'' N	$6^0$55'08'' W	14	$41^0$36'17'' N	$6^0$42'27'' W
3	$41^0$50'53'' N	$6^0$56'02'' W	15	$41^0$36'38'' N	$6^0$41'01'' W
4	$41^0$47'45'' N	$6^0$59'09'' W	16	$41^0$40'51'' N	$6^0$41'24'' W
5	$41^0$47'37'' N	$6^0$57'21'' W	17	$41^0$38'22'' N	$6^0$36'03'' W
6	$41^0$53'21'' N	$6^0$55'06'' W	18	$41^0$33'52'' N	$6^0$37'19'' W
7	$41^0$45'43'' N	$6^0$48'09'' W	19	$41^0$33'50'' N	$6^0$37'20'' W
8	$41^0$47'29'' N	$6^0$49'09'' W	20	$41^0$31'27'' N	$6^0$33'16'' W
9	$41^0$47'59'' N	$6^0$48'22'' W	21	$41^0$29'51'' N	$6^0$32'24'' W
10	$41^0$46'34'' N	$6^0$45'25'' W	22	$41^0$28'35'' N	$6^0$24'53'' W
11	$41^0$52'07'' N	$6^0$45'09'' W	23	$41^0$25'30'' N	$6^0$20'34'' W
12	$41^0$33'56'' N	$6^0$43'23'' W			

5. Experimental materials identification and characterization

The adopted designation for the above each construction will be related to the designation used for the different material samples collected and studied following (eg. sample 1 refers to construction 1).

As mentioned above, this research, as mentioned above, includes the collection of buildings material samples, when it was possible. In fact, *tabique* dwellings were found in all Municipalities of the AMTFNT. However, it was not possible to obtain samples from all of them because we did not get permission from the owners and others were in ruins.

In order to identify and to characterize the materials traditionally used in the *tabique* constructions, an experimental campaign was performed using the materials samples collected from the studied constructions.

Apart from the metal nails used to connect the timber elements, the most relevant *tabique* building materials are natural and local.

5.1. Mortar

According to the results obtained in [1-9] it has been noticed that the material used for coating the timber structure of *tabique* buildings components can be earth alone or an earth based mortar.

5.1.1. Granulometric analysis

In this research work, it was only possible to collect one mortar sample, Figure 5, to do the granulometric analysis. This fact is justified taking into the difficulty of obtaining material samples. In this case, an expressive amount of material is required to perform this test.

The granulometric curve obtained is shown in Figure 6. The sample was collected in building 15.

Figure 5: Mortar sample for granulometric analysis

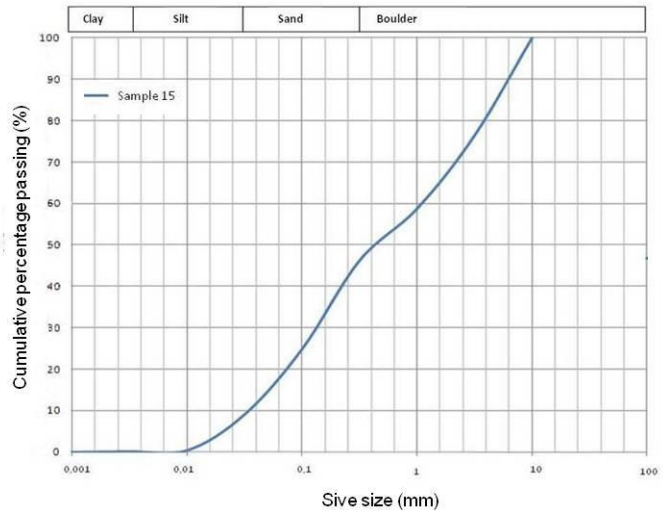


Figure 6: Granulometric curve

5.1.2. SEM/EDS and X-RAY analysis

In order to identify the chemical and mineralogical elementary composition of the mortars samples collected, SEM/EDS and X-ray test were performed. Two examples of the material samples used in this study are shown in Figure 7.

The results obtained by the SEM/EDS test are presented in Table 2 and the results of the X-ray test are shown in Table 3.

Figure 7: Samples for the SEM/EDS and X-ray tests

Table 2: Results of SEM/EDS Elementary chemical composition

Chemical Element (%)	Sample							
	1	2	3	4	13	15	17	22
O	49,61	53,46	46,41	53,69	46,30	50,03	48,78	49,47
F	1,17	--	0,75	--	--	--	0,66	0,73
Na	0,78	0,49	3,16	--	0,36	--	0,7	0,49
Mg	9,85	12,96	11,34	12,73	6,37	6,88	7,67	9,13
Al	2,51	1,12	4,36	1,11	9,12	4,08	4,11	3,42
Si	6,08	5,2	8,53	4,95	10,89	7,44	14,19	7,45
Cl	--	--	4,03	--	--	--	0,07	--
K	0,52	0,16	1,01	0,25	2,84	1,19	1,08	1,11
Ca	26,56	24,68	16,97	24,91	20,40	28,06	20,04	25,51
Mn	0,39	0,36	0,23	0,32	0,25	--	--	--
Ti	0,29	--	0,27	--	--	0,13	0,28	0,34
Fe	2,25	1,57	2,95	2,03	3,46	2,21	2,43	2,33

The chemical elements identified were oxygen (O), sodium (Na), magnesium (Mg), aluminum (Al), silicon (Si), chlorine (Cl), potassium (K), calcium (Ca), manganese (Mn), titanium (Ti) and iron (F).

Table 3: Results of the X-ray elementary mineralogical composition

	Mineralogical composition			
Sample	Calcite	Quartz	Muscovite	Albite
1	✓	✓	x	X
2	✓	✓	✓	X
3	✓	✓	✓	X
4	✓	✓	x	X
13	✓	✓	✓	X
15	✓	✓	✓	X
17	✓	✓	✓	X
22	✓	✓	✓	✓

According to Table 2, the results indicate an unexpected high quantity of calcium existing in the earth-based mortar studied. This conclusion contrasts with results obtained [1-9] in which was found coating without calcium.

5.3. Timber

During the field work, it was possible to get timber samples from five buildings (building 1, 3, 4, 15 and 17). Figure 8 shows some of these samples.

a) Building 1 b) Building 3 c) Building 4 d) Building 15 e) Building 17

Figure 3: Timber Samples

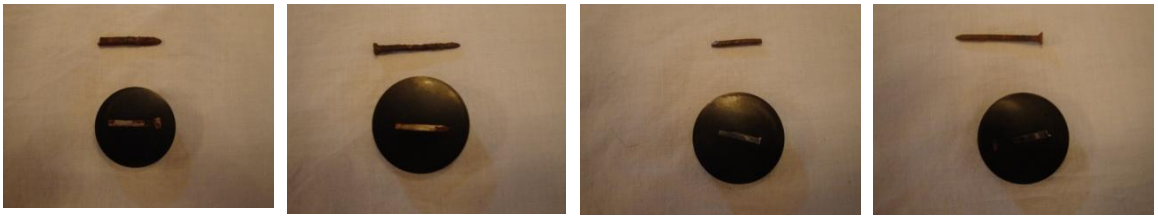
Table 4: Identification of the species of the timber samples

Sample	Wood Species
1	*populus sp*
3	*pinus pinaster*
4	*pinus pinaster*
15	*pinus pinaster*
17	*pinus pinaster*

It was concluded that the *pinus pinaster* is the most common type of wood traditionally used in the timber structural components of the tabique elements of the AMTFNT, Table 4.This result is in accordance to the results obtained in [1-9].

5.4. Nails

It was possible to obtain nail sample in buildings 1, 4, 15 and 17 as it is shown in Figure 9.



a) Building 1 b) Building 4 c) Building 15 d) Building 17

Figure 4: Nail Samples

Table 5 summarizes some results of the material characterization of the nail samples.

Table 5: Hardness of the nails

Sample	1	4	15	17
Highness Vickvers (HV)	312,50	287,00	279,00	270,00

From the characterization tests of these connectors, the experimental results indicate that these nails are made of steel, because HV is higher than 200.

6. Conclusion

Trás-os-Montes e Alto Douro is a region rich in *tabique* constructions. The AMTFNT also confirms this fact.

Generally, the constructions that have *tabique* elements in the AMTFNT are dwellings of two floors. The *tabique* elements are more commonly used as interior partion wall. However, exterior tabique walls can also be frequently founded at the upper floors.

The most common structural material used in the *tabique* elements is the *pinus pinaster* timber, being the timber elements connected by steel nails. In addition, this structural support system is normally covered on both sides by an earth-based material instead of conventional mortars.

During this research work, the most difficult task faced was the collection of building material samples. More samples and bigger quantity of coating samples are required to allow drawing more representative conclusions about the type coating used in the AMTFNT.

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